CLAIMS

What claimed is:

1.- An image reconstruction method comprising: (*a*) obtaining the measurement data corresponding to the image; (*b*) processing said measurement data using heuristic non-linear global optimization , specifically the Method of Simulated Annealing in order to obtain an image; and (*c*) displaying said processed image on a display device.

2.- A method according to claim 1, wherein the measurement data are electrical parameters on the perimeter of a region such as the inside of a pipeline, of the oil well or of the a tank, for the obtained image of the spatial distribution of the electrical permittivity (or dielectric constant) or of the electrical conductivity within said region, and the image reflects the spatial distribution of the materials or substances that occupy the region, such as gases or/and liquids.

3.- A method according to claim 2, wherein said parameters are the electrical capacitance values measured between the electrodes of a sensor, which is formed by a plurality of said electrodes placed around the perimeter of the region (pipeline, well, tank).

4. A method according to claims 2 and 3, wherein said the image obtained is an image of the spatial distribution of the electrical permittivity (or dielectric constant) within said interest region (pipeline, well, tank)., which reflects the spatial distribution of the materials or substances, such as gases or/and liquids, that occupy this region (pipeline, well, tank).

5.- A method according to claims 2 to 4, wherein said the image is formed by a finite number of sub-regions or pixels in the viewing, which number depends on the desired resolution.

6.- A method according to claim 3, wherein said sensor is formed by a pipe made of an electrically insulating material, on whose outer wall an array of rectangular metallic electrodes is placed.

7.- A method according to claims 3 and 6, wherein the sensor contains a multiphase or multicomponent flow, and images that show the distribution of the phases or components, such as gases or/and liquids, are obtained in accordance to what is said in the background of the invention.

8.- A method according to claim 1, wherein the method of simulated annealing is used as the optimization method.

9.- A method according to claim 8, wherein a cost function associated to the energy of the system is iteratively minimized with respect to ε (the vector of the permittivity values in each pixel of the image), said cost function being of the form:

$$E_k = L_{2(k)} = \frac{\sum_{i=1}^{m}\left[c_i^{meas} - c_i^{calc}(\varepsilon_k)\right]^2}{\sum_{i=1}^{m}\left[c_i^{meas}\right]^2} \qquad (i = 1, \ldots, m)$$

where c_i^{meas} are the m measured mutual capacitances and $c_i^{calc}(\varepsilon_k)$ are the ones calculated by solving the forward problem for a given permittivity distribution ε_k.

10.- A method according to claim 9, wherein the Metropolis criterion is used to do the minimization.

11.- A method according to claim 10, wherein in the minimization process it is used, as the initial guess for the permittivity distribution, ε, both a homogeneous distribution and the distribution that results from applying the linear back-projection (LBP) method to the measurement data.

12.- A method according to claim 9, wherein the computation of the calculated capacitances $c_i^{calc}(\varepsilon_k)$, known as the forward problem, is carried out by means of the finite-volume method.

13.- A method according to claim 12, wherein for the solution of the system of equations that results from solving the forward problem $c_i^{calc}(\varepsilon_k)$, iterative methods that rapidly converge are used, by employing as initial estimation of the electrostatic potential the result of the forward problem solution obtained in the previous iteration of the inverse problem.

14.- A method according to claim 1, wherein the method of genetic algorithms is used as the optimization method.

15.- A method according to claim 14, wherein, starting from an initial population of Q permittivity models $\varepsilon_{k(o)}$ ($k = 1, \ldots, Q$), evolutionary mechanisms such as selection, crossover and mutation are applied in order to obtain new populations.

16.- A method according to claim 15, wherein individuals ε_k are characterized by having a small cost (or misfit) function, which is given by

$$E_k = L_{2(k)} = \frac{\sum_{i=1}^{m}\left[c_i^{meas} - c_i^{calc}(\varepsilon_k)\right]^2}{\sum_{i=1}^{m}\left[c_i^{meas}\right]^2} \qquad (i = 1, \ldots, m)$$

where c_i^{meas} are the m measured mutual capacitances and $c_i^{calc}(\varepsilon_k)$ are the calculated ones by solving the forward problem for a given model or permittivity distribution ε_k.

17.- A method according to claims 15 and 16, wherein the accumulated probability of selection for a particular model ε_k is given by

$$P(\varepsilon_k) = P(\varepsilon_{k-1}) + \frac{E_{max} - E(\varepsilon_k)}{Q\,(E_{max} - E_{avr})}$$

where E_{max}, and E_{avr} are maximum and average cost functions of the generation, respectively, and Q is the number of individuals in the population.

18.- A method according to claim 17, wherein a biased roulette procedure can be used to decide which models are selected on each iteration of the method.

19.- A method according to claim 18, wherein crossover and mutation of models are carried out randomly according to the probabilities of crossover and mutation, P_c y P_m.

20.- A method according to claim 19, wherein the probability of mutation P_m is determined using the average variation coefficient γ, given by

$$\gamma = \frac{1}{p}\sum_{i=1}^{p}\left(\frac{\sigma_i}{\bar{\varepsilon}_i}\right)$$

where p is the number of parameters, $\bar{\varepsilon}_i$ is the average of the i-th parameter, and σ_i is the standard deviation.

21.- A method according to claims 19 and 20, wherein P_m is defined as a function of γ, that is:

$$P_m = \begin{cases} P_{ini} & \text{para} \quad \gamma > 0.1 \\ 0.1 & \text{para} \quad 0.02 < \gamma < 0.1 \\ 0.2 & \text{para} \quad \gamma < 0.02 \end{cases}$$

where P_{ini} is the initial probability of mutation.

22.- A method according to claims 15 and 16, wherein the calculation of $c_i^{calc}(\varepsilon_k)$, known as the forward problem, is performed by means of the finite-volume method.